AN INTRODUCTION TO REED DEVICE APPLICATIONS

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INTRODUCTION

In a relatively short period of years, the dry reed switch has begun to play an important role in a wide variety of electronic and electro-mechanical equipment. Current major applications range from telephone switchgear, appliances, and data processing units to logic circuitry for industrial controls. New applications are increasing at such a rapid rate that it is virtually impossible to keep track of them.

Reed switches are applicable wherever it is necessary, or desirable, to have a small, simple, high-speed switching device that requires a minute amount of current for operation.

An Engineering Design Kit (Part No. 67-001) is offered by New Product Engineering as a designer's tool to enable him to attain a "feel" for reed devices. It is recommended that a designer with serious interest in reed devices and their applications obtain one of these kits, as a reasonable level of confidence and familiarity with the reed switch, its characteristics and its limitations, will allow the user to apply these devices realistically in his design or end product.

All of the circuits included herein can be constructed using the parts in the design kit. (See page 6, appendix, for ordering information.)

I. DESCRIPTION OF PARTS

A. Reed Switches...

The New Product Engineering reed switch capsule consists of a pair of low reluctance, ferromagnetic, flat metal reeds, hermetically sealed in an atmosphere of dry inert gas. The reeds are of equal length and are fused into the ends of a glass tube in cantilever fashion so that their extreme ends align and overlap with a gap of about 0.01 inch between them.

When this assembly is placed in a magnetic field, the reeds become a flux-carrying portion of the magnetic circuit. The extreme ends of the reeds assume opposite magnetic polarities, and, if sufficient flux is present, the attraction forces overcome the stiffness of the reeds and they flex toward each other and touch, forming a normally open, single pole, single throw (SPST) switch.

Wide differences in performance and ratings occur due to the variety of materials used in construction of reed switches, differences in reed lengths, contact materials, metal-glass sealing techniques, etc. It is extremely important to keep these differences in mind when initially selecting a reed switch or when changing from one manufacturer to another.

The test circuits depicted in the appendix (page 5) are used to determine two typical reed switch characteristics. Standard coils, similar to those included in the design kit, are used to measure ampere turn (NI) sensitivity in the first circuit. These circuits may be constructed to measure the specific sensitivity and contact resistance of the NPE Reed Switches provided with the kit.

These switches lie within three arbitrarily assigned sensitivity ranges, coded blue, green or red. The specific value may be measured using the pull-in and drop-out sensitivity circuit on page 5 of the appendix.

B. Test Coils...

The coils provided in the design kit (Table 1) are typical of the electro-magnetic inductors necessary for actuating the reed switch.

The two Test Coils (illustrated page 3, appendix) are used to verify the ampere turn sensitivity of reed switches. By choice of core size, switch sensitivity, wire gauge and number of turns, relays of a wide operational range can be designed. The Logic Coil (Table 1) consists of three isolated windings, the center one of which has approximately one-half as many turns as the two outer windings.

A reed relay coil normally is expected to satisfy certain mechanical requirements as a container for the reed switches and magnets, etc.; therefore, a nylon bobbin is often used as the core. For maximum effectiveness, coil placement and distribution (along the switch axis) with respect to the magnetic gap dictates the use of a short coil carefully centered over the air gap; however, this would not produce the most desirable physical package.

In relay design, the allowable coil dimensions must first be established. Once the mechanical specifications are established, a coil can be designed to operate the switch over a range of from one to one-hundred volts. When a specific voltage or functional sensitivity and size are already fixed by an intended application, judicious selection of switch, wire size and number of turns will enable fulfillment of the requirements. Optimization of a coil-switch combination for a given job means that all factors must be balanced.

TABLE 1 NPE COILS FOR REED SWITCHES

Standard Test Coil

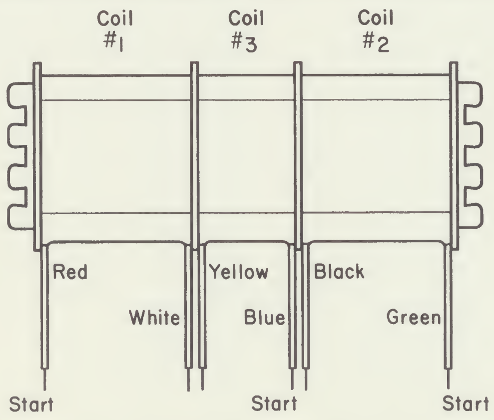
Part No.	Turns	Resistance @ 25°C
60-4988	10000	650 Ohms, +10%, -0%

Miniature Test Coil

Part No.	Turns	Resistance @ 25°C
60-0007	10000	1650 Ohms, +10%, -0%

Logic Coil

Part No.	Turns	Resistance @ 25°C
60-002-1	#1 6300, +0%, -2%	1230 Ohms, +10%, -0%
	#2 6300, +0%, -2%	1230 Ohms, +10%, -0%
	#3 2500, +0%, -2%	765 Ohms, +10%, -0%



C. Bias Magnets...

Permanent magnets are often employed as part of the controlling mechanism of sealed reed devices. The reed switch and coil with a permanent magnet is a very flexible combination which can be arranged in many magnetic/mechanical configurations.

The basic purpose of the magnet is to induce a magnetic field in the switch air gap. This field may be a positive bias (latching relay); a negative bias (form B relay); or sufficient in itself to affect a closure of a form A switch (proximity transducer).

Many types of magnets are commercially available, and, although each of us has a familiarity with them and with what they do, a brief but meaningful synopsis of the mechanical and electrical characteristics is nearly impossible. A valid explanation of the intrinsic properties (magnetomotive force, flux density, reluctance, hysteresis, etc.) would require an examination of electric and magnetic field theory and atomic physics.

In a permanent magnet/switch application, the switch reeds complete the magnetic circuit, offering the path of least reluctance to the field established by the magnet.

The elusive qualities of flux (determined by the magnet's MMF) and the lack of a true magnetic insulator introduce the designer to many challenges. The potential driving force available with a given permanent magnet depends upon its size (cross-sectional area with respect to length) and relationship to the air gap in which the flux is desired.

Care must be exercised when circuits are designed using permanent magnets, as the circuit must compensate for changes in magnetic field strength during life and, if barium ferrite magnets are used, temperature compensation is also necessary.

For data on the two magnets included in the design kit, see page 4, appendix.

II. PARTS LIST, ENGINEERING DESIGN KIT (PART NO. 67-001)

Quantity	Description	NPE Part No.	Remarks
3	Reed Switch-Standard Size	69-4321-1	Red (30 to 40 NI)
3	Reed Switch-Standard Size	69-4321-1	Green (55 to 70 NI)
3	Reed Switch-Standard Size	69-4321-1	Blue (85 to 110 NI)
2	Reed Switch-Miniature Size	69-2221-1	Red (30 to 40 NI)
2	Reed Switch-Miniature Size	69-2221-1	Green (50 to 70 NI)
2	Reed Switch-Miniature Size	69-2221-1	Blue (80 to 100 NI)
1	Standard Test Coil	60-4988	Table 1 (page 2)
1	Miniature Test Coil	60-0007	Table 1 (page 2)
1	Logic Coil	60-002-1	Table 1 (page 2)
2	Permanent Magnet	24-05001-1006	1/4" sq. x 1" lg.
2	Permanent Magnet	24-05001-1002	1/8" sq. x 3/4" lg.

III. ASSEMBLY EXAMPLES

No attempt has been made to offer detailed procedures for assembling reed switch devices. The designer's personal preference and techniques are to be used to the fullest extent, using these parts and functional design considerations described as an introductory aid.

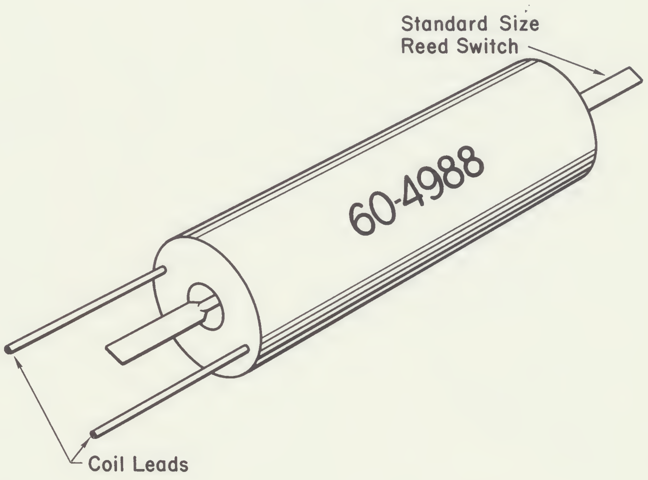
The following assemblies are typical of the functional devices which can be made with the design kit:

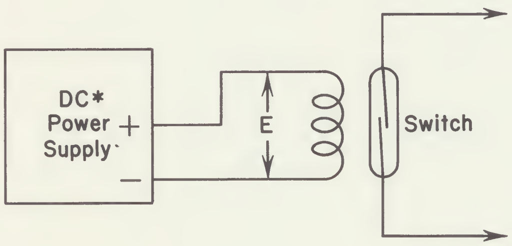
* Note: The direct current driving voltage need be only reasonably filtered for all examples.

A. Electromagnetic Relays

1. Standard size relay - SPST - Normally Open

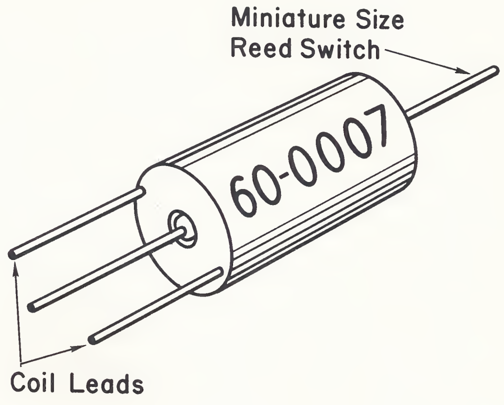
Switch Sensitivity	Nominal Voltage (E)
Red	6 VDC
Green	9 VDC
Blue	12 VDC

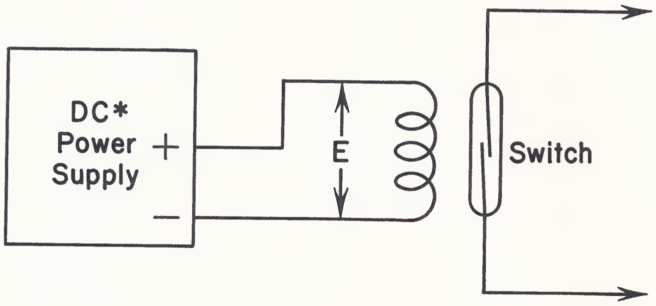




2. Miniature size relay - SPST - Normally Open

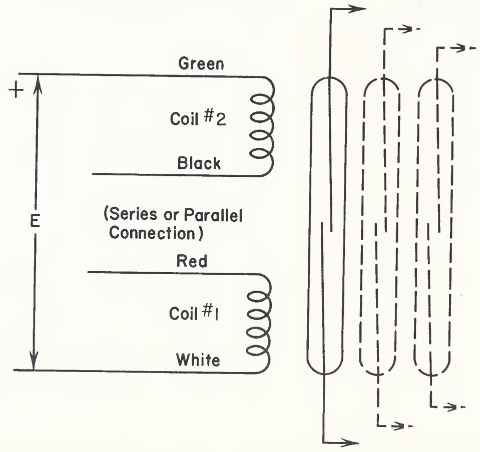
Switch Sensitivity	Nominal Voltage (E)
Red	12 VDC
Green	24 VDC
Blue	30 VDC

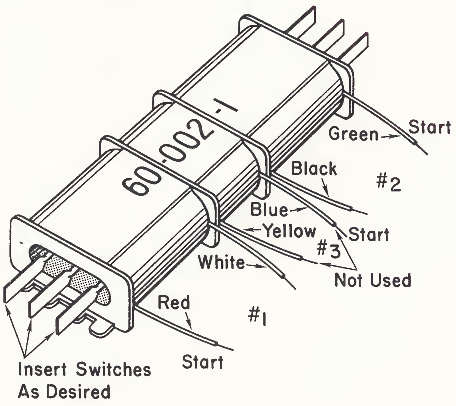




3. Multiple contact relay - SPST, DPST, 3PST - Normally Open

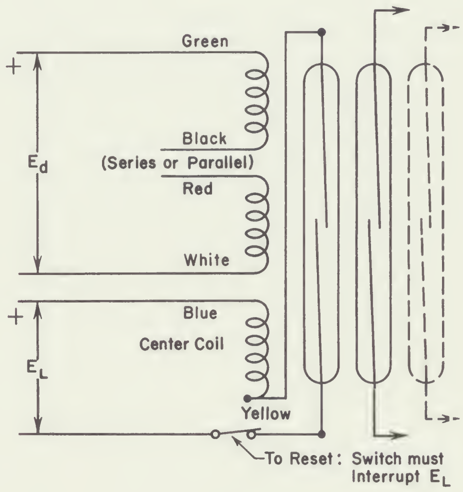
Switch Sensitivity	Nominal Voltage (E) Windings 1 & 2	
	Series	Parallel
Red	12 VDC	6 VDC
Green	24 VDC	12 VDC
Blue	48 VDC	36 VDC





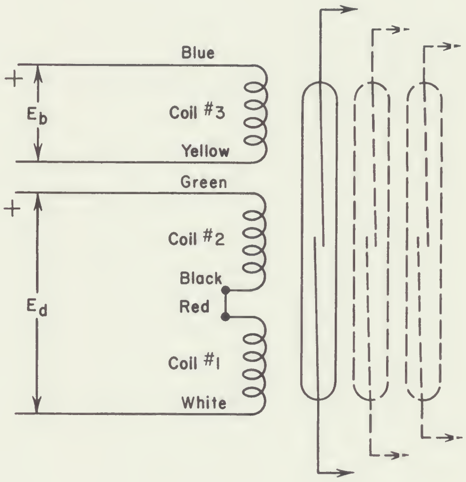
4. Electrical latching relay
Similar to (3.) except using coil No. 3 as a positive bias (latch) coil.

Switch Sensitivity	Driving Voltage(E_d)		Latch Voltage (E_L)
	Series	Parallel	
Red	12 VDC	6 VDC	6 VDC
Green	24 VDC	12 VDC	12 VDC
Blue	48 VDC	36 VDC	12 VDC



5. Multiple contact relay - SPST, DPST or 3PST
Normally closed (electrically biased).

Switch Sensitivity	Driving Voltage (E_d)	Bias Volts (E_b)
Red	12 VDC	-12 VDC
Green	24 VDC	-24 VDC
Blue	48 VDC	-48 VDC

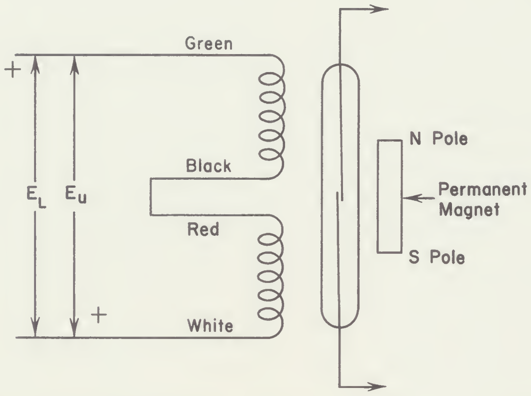


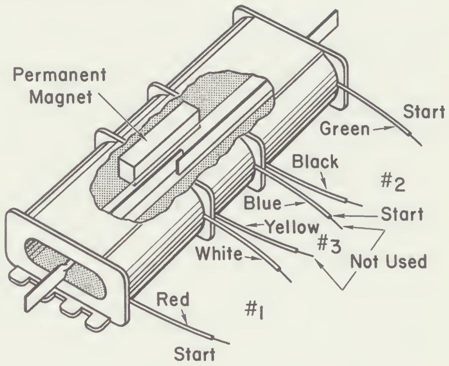
Note: Coil No. 3 is permanently energized, producing a normally closed switch which is opened by the cancellation effect of energizing series-connected coils No. 1 & 2.

6. Magnetic latching relay - SPST - Normally open

Permanent Magnet No. 24-05001-1002 (Magnet/coil orientation is critical)

Switch Sensitivity	Latch Voltage (E_L)	Unlatch Voltage (E_u)	Magnet Spacing
Blue	24 VDC	-12 VDC	1/8 to 3/16 inch from switch



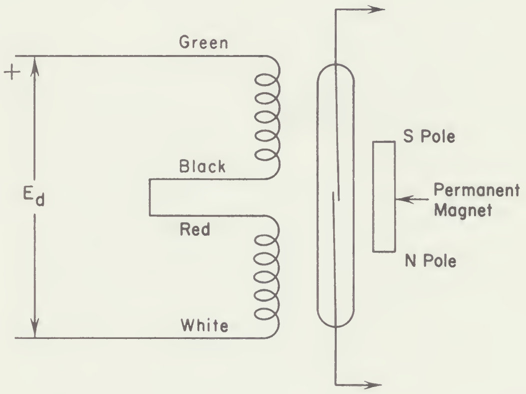


Note: The permanent magnet must be centered and mechanically held (with a non-magnetic spacer) 1/8 to 3/16 inch from the nearest surface of the reed switch, and oriented as shown, with its north pole toward the green (positive) lead. After assembly, momentarily apply unlatch voltage to "clear" possible latched condition.

7. Permanent magnet biased relay - SPST - Normally closed

Permanent Magnet No. 24-05001-1002 (Magnet/coil orientation is critical)

Switch Sensitivity	Driving Voltage (E_d) Series	Magnet Spacing
Red	24 VDC	Adjacent to switch
Red	12 VDC	1/4" from switch
Green	24 VDC	Adjacent to switch
Green	18 VDC	1/8" from switch



Note: If excess driving voltage is applied, the switch will close again -- reeds will reverse polarity.

B. Computer Logic Elements

It is in the area of logic devices that reed switch/coil combinations exhibit their full potential.

The reed relay is a natural logic element for automation. For example, the simple normally open relay is a logic amplifier (of approximate unity gain), and a normally closed relay is a logic inverter.

The primary computer logic building blocks are: the INVERTER; the AND gate; and the OR gate. The various forms of logic used in specific systems are merely adaptations or combinations of these three "blocks"; e. g. NOR and NAND logic concepts are negative OR and negative AND functions.

Computer elements designed with reed relays allow several independent logic functions to be actuated with a single input, or, with isolation diodes added to the input line, devices such as multiple input AND gates.

AND, OR, NAND and NOR circuits can be constructed by using any desired number of single pole normally open or normally closed relays, with the coils independently driven by the functions to be interpreted, and the output contacts connected either in series (AND) or parallel (OR). However, a much more economical technique of construction is to use multiple windings on a common form, enclosing whatever number of switches are necessary for the desired function.

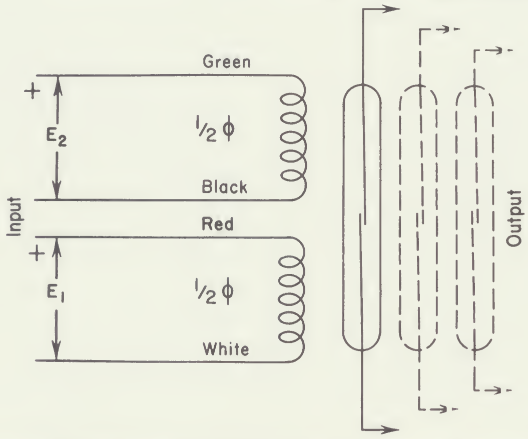
When designing circuitry with double or triple-winding reed relays, the amount of magnetic flux required to adequately actuate the reed switch must be considered. The necessary actuating force is normally referred to as one flux unit (Symbol: ϕ). This one flux unit can be supplied by current through the coil or a portion of the coil from one voltage source, while another percentage of the total flux unit can be supplied from a second source.

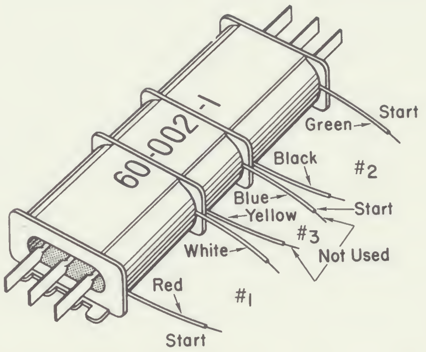
In example III B. 1., it is obvious that if one-half flux unit is supplied from coil number 1, and one-half flux unit supplied from coil number 2, a convenient "AND" logic circuit is formed. Examples 2 through 5 depict a few other possibilities of logic elements to be constructed with reed switches and common coil combinations.

1. AND Circuit

Switch Sensitivity	Input Voltage	
	E_1	E_2
Red	6 VDC	6 VDC
Green	12 VDC	12 VDC
Blue	24 VDC	24 VDC

Relay Truth Table		
Coil No. 1	Coil No. 2	Output
0	0	0
+	0	0
0	+	0
+	+	+

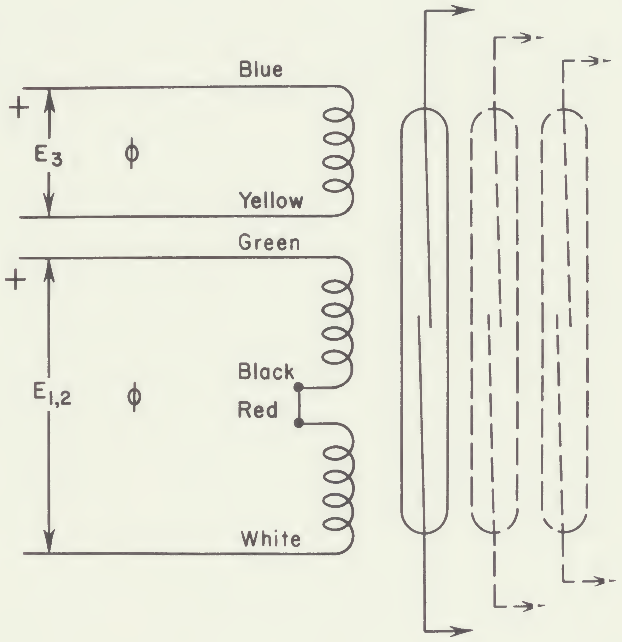




2. OR Circuit (more specifically, the inclusive OR)

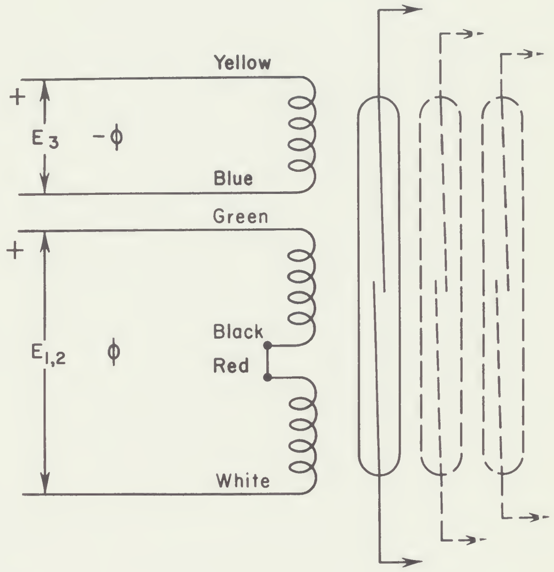
Switch Sensitivity	Input Voltage	
	$E_{1,2}$	E_3
Red	18 VDC	18 VDC
Green	24 VDC	24 VDC
Blue	48 VDC	48 VDC

Relay Truth Table		
Coil No. 1,2	Coil No. 3	Output
0	0	0
+	0	+
0	+	+
+	+	+



3. EXOR (exclusive OR)

Switch Sensitivity	Input Voltage	
	$E_{1,2}$	E_3
Red	18 VDC	-18 VDC
Green	24 VDC	-24 VDC
Blue	48 VDC	-48 VDC

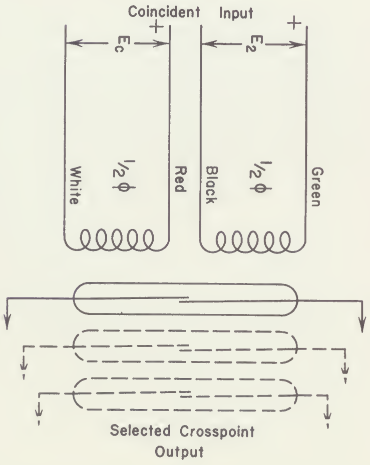


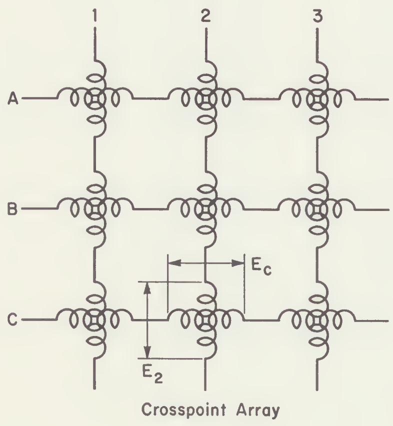
Relay Truth Table		
Coil No. 1,2	Coil No. 3	Output
0	0	0
+	0	+
0	+	+
+	+	0

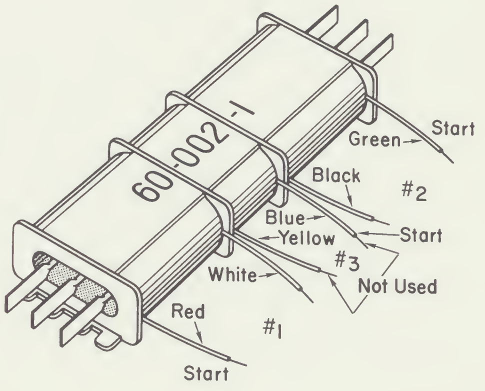
4. Single Mode Matrix Element

The single-mode crosspoint matrix element is merely an AND circuit situated within a crosspoint array. Each potential selection point (x and y coordinates) comprises a double winding relay, which is energized by a matrix coincidence. With loss of this input coincidence, however, the output switch actuation will also be lost.

Switch Sensitivity	E_2 and E_c Crosspoint Potential Required (E)
Red	6 VDC
Green	12 VDC
Blue	24 VDC

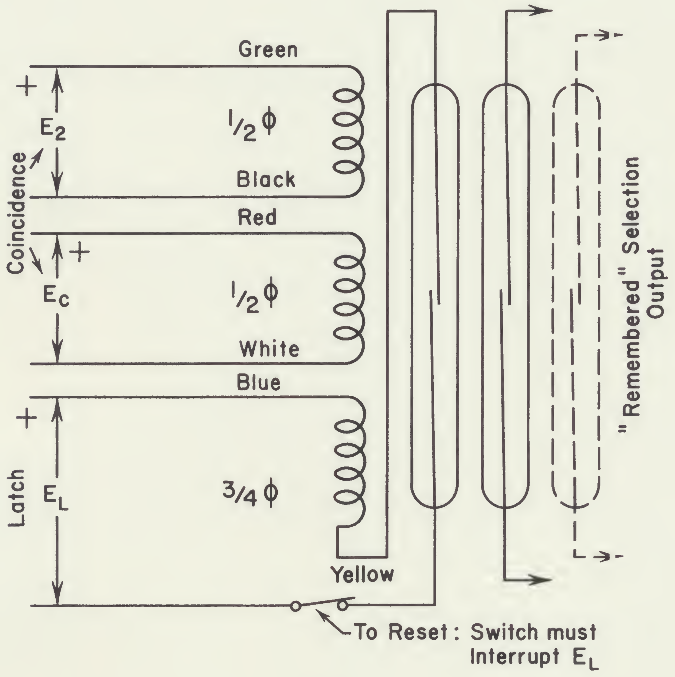






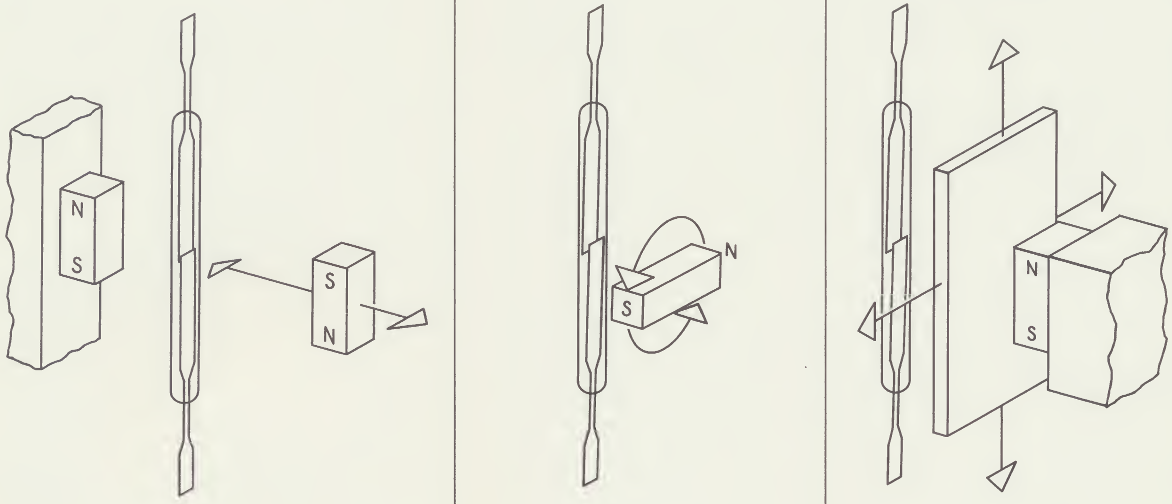
5. Element of a Crosspoint Memory Matrix
Same as example B. 4. except with the use of one switch for self latching (memory).

Switch Sensitivity	E_2 and E_c	E_{Latch}
Red	6 VDC	6 VDC
Green	12 VDC	12 VDC
Blue	24 VDC	12 VDC



C. Proximity Transducers

Permanent magnet actuation of the reed switch can assume an infinite variety of magnetic-mechanical configurations. Each unique application displays subtle differences; however, they all employ one or some combination of four basic techniques: proximity switching, shielding, rotation, and biasing. To affect reed switch closure, the magnet needs only to induce adequate MMF (flux density) into the reed air gap. This is accomplished by the magnet being close enough, strong enough, and parallel to the reeds, without being influenced by outside magnetic fields or nearby flux shunting paths.



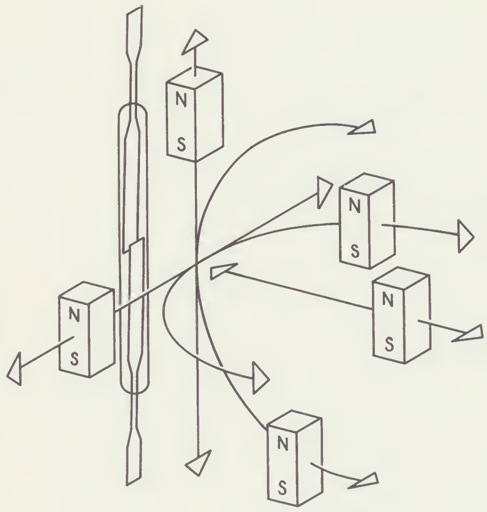
1. 2. 3.

1. Biasing -- A fixed magnet achieves a normally closed switch. The field of the biasing magnet is overcome by that of the actuating magnet to open the switch.

2. Rotation -- Magnet rotation actuates the switch. In some applications, the switch is rotated adjacent to a stationary magnet.

3. Shielding -- In this switching technique, a movable shield prevents formation of a magnetic flux field at the switch.

4. Proximity Switching -- There are several basic approaches for proximity switching. The arrows indicate the movement of the permanent magnet.



4.

IV. OPERATION AND APPLICATION CONSIDERATIONS

When designing reed devices or circuits, several factors must be considered. This list is not necessarily complete nor in order of importance, but the designer must realize that the reed switch or reed relay may not be the ideal solution to every application problem, for it does have certain limitations.

1. Contact ratings (refer to switch or relay specifications).
2. Contact arc suppression.
3. Coil EMF suppression (deleterious effects of back EMF spike on other circuit components).
4. Effects of back EMF suppression on actuation speed.
5. Magnetic shielding (ambient flux fields, flux leakage, etc.).
6. Environment (temperature, humidity, shock, vibration).
7. Polarities of coils and magnets.
8. Magnet aging compensation.
9. Proper application -- should transistors be selected (due to high-speed switching requirements)?
10. Proper application -- should power relays be chosen (due to contact requirements)?

Thorough analysis of these factors and their effects upon an application can prevent many hardware problems.

V. POTENTIAL FUNCTIONS

The reed switch has matured into an extremely dependable, virtually miss-free device, and refinements in processing and manufacturing techniques are resulting in even better products. Its applications are now extending into areas of high reliability requirements such as data processing and computing, and medical electronics.

Some of the current and potential applications for reed devices include:

TELEPHONE CENTRAL OFFICE
- Channel switching
- Crosspoint selection
- Circuit scanning
- Pulsing and memory circuits

COMPUTERS
- Card sorting
- Programming control
- Logic circuits

INDUSTRIAL EQUIPMENT
- Burglar alarms
- Liquid and gas flow meters
- Limit switches
- Level indicators
- Position indicators
- Safety devices
- Temperature sensors
- Weighing devices
- Pressure controls
- Vending machines
- X-ray equipment
- Rotary switching
- Time delay
- Pulse shaping
- Antenna switching
- Barricade flashers
- RPM counters
- Magnetic tape controls

CONSUMER PRODUCTS
- Toys
- Refrigerators
- Washers
- Dryers
- Dishwashers
- Automatic lighting controls
- Door chimes
- Intercommunication systems
- High fidelity and audio equipment

Future applications are limited only by the imagination of the designer.

NOTES